



UNIVERSITI PUTRA MALAYSIA

**IMPROVING LIQUID FERTILIZER UREA EFFICIENCY
USING HUMIC ACIDS ADDITIVES
EXTRACTED FROM TROPICAL PEAT**

SUSILAWATI BINTI KASIM

FP 2009 1

**IMPROVING LIQUID FERTILIZER UREA
EFFICIENCY USING HUMIC ACIDS ADDITIVES
EXTRACTED FROM TROPICAL PEAT**

SUSILAWATI BINTI KASIM

**DOCTOR OF PHILOSOPHY
UNIVERSITI PUTRA MALAYSIA**

2009



**IMPROVING LIQUID FERTILIZER UREA EFFICIENCY
USING HUMIC ACIDS ADDITIVES EXTRACTED FROM
TROPICAL PEAT**

By

SUSILAWATI BINTI KASIM

**Thesis Submitted to the School of Graduate Studies,
Universiti Putra Malaysia, in Fulfilment of the Requirement for
the Degree of Doctor of Philosophy**

June 2009



DEDICATION

Dedicated to all people who have contributed their brilliant ideas, wisdom words and efforts to finish this thesis. It is also dedicated to those who have helped me along my way, during my hard time in finishing my study.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in
fulfillment of the requirements for the degree of Doctor of Philosophy

**IMPROVING LIQUID FERTILIZER UREA EFFICIENCY USING HUMIC ACIDS
ADDITIVES EXTRACTED FROM TROPICAL PEAT**

By

SUSILAWATI KASIM

June, 2009

Chairman : Osumanu Haruna Ahmed, PhD

Faculty : Faculty of Agriculture and Food Sciences

One of the most important sources of organic matter is peat. Being organic in nature, peat are high in humic and fulvic acids. These substances can be reconstituted with N and K to produce ammonium and potassium-humates (organic fertilizer). This could be realized if they could be rapidly and cheaply isolated from peat soils. Factors which affect the humic and fulvic acids isolation from soils include extraction, fractionation, and purification periods. Thus, part of this study investigated whether a relationship could be separately established between extraction time, fractionation time, and the yield of humic acids (HA) of tropical peat soil (hemists), as well as the relationship between both variables on the yield of HA of this soil. Modified standard procedures using 0.1 M KOH (analytical grade) were used to isolate humic acids from the soil. Results showed that, there was a quadratic relationship between extraction period and yield of HA. There was however no relationship between fractionation period and yield of HA. There was negative correlation between the yields of extraction and fractionation periods. This finding enables the isolation of HA of hemists in

less than 10 h instead of existing average period of 2 to 7 days, therefore helping in facilitating the idea of producing for instance ammonium-humate or potassium-humate (N and K foliar organic fertilizers) from peat. The second part of the study was development of NH_4^+ -K-humate by reconstitution of humic and fulvic acids. The organic fertilizers developed via reconstitution were evaluated under laboratory conditions. Effectiveness of organic fertilizer in enhancing N availability was the main concern of this study. This was due to high N loss by N fertilizer (e.g. urea) after surface application. Nine treatments namely urea (solid), urea (liquid), ammonium sulfate (solid), ammonium sulfate (liquid), humic acids + urea, fulvic acids + urea, humic and fulvic acids (acidified) + urea and humic, fulvic acids (unacidified) + urea and control (soil alone) were used in this study with the aim of reducing N loss from urea application. A closed dynamic air flow system was used to estimate N loss from soil. Usage of fulvic together with urea decreased soil pH and as well as ammonia volatilization. However, the use of HA significantly reduced ammonia volatilization. This suggests the effectiveness of the organic based fertilizer formulated in controlling N loss and enhancing N availability. Besides being effective in controlling N loss, promotion of plant growth and development are other factors which should be considered in order to confirm the effectiveness of the formulated organic fertilizer. Hence, a pot experiment (third part of the study) was set up with seven treatments excluding liquid ammonium sulfate. Results showed that, organic based N fertilizers enhanced N, P and K uptake. They also promoted N use efficiency particularly for the treatments with fulvic acids. Thus, the formulated fertilizers

(organic fertilizers) have the potential to serve as an alternative fertilizer in reducing N loss, enhancing nutrient uptake and N use efficiency.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**PENAMBAHBAIKAN KEBERKESANAN BAJA CECAIR UREA DENGAN
MENGUNAKAN ADITIF ASID HUMIK YANG DIEKSTRAK DARIPADA
TANAH GAMBUT TROPIKA**

Oleh

SUSILAWATI BINTI KASIM

Jun, 2009

Pengerusi : Dr. Osumanu Haruna Ahmed, PhD

Fakulti : Sains Pertanian dan Makanan

Salah satu sumber bahan organik yang penting adalah gambut. Ianya adalah organik secara naturalnya dan tinggi kandungan asid humik dan fulvik. Kedua-dua asid ini boleh digabungkan dengan N dan K untuk menghasilkan amonium dan potasium-humate yang boleh dikategorikan sebagai baja organik. Ianya adalah lebih baik jika asid humik dan fulvik dapat diisolasi dengan lebih cepat dan murah daripada tanah gambut. Beberapa faktor mempengaruhi isolasi asid humik dan fulvik ini seperti jangka masa pengekstrakan, penyisihan dan penulenan. Maka, sebahagian daripada kajian ini adalah meneliti samada terdapat perhubungan yang berasingan antara masa pengekstrakan dan masa penyisihan dengan asid humik yang dihasilkan daripada tanah gambut tropika (*hemists*). Begitu juga perkaitan di antara kedua-dua faktor tadi dengan asid humik yang dihasilkan. Kaedah piawai yang telah diubahsuai yang menggunakan 0.1 M KOH (gred analitikal) telah digunakan dalam mengisolasi asid humik daripada tanah. Keputusan menunjukkan terdapat perhubungan

kuadratik di antara jangkamasa pengekstrakan dengan asid humik yang dihasilkan. Manakala tidak ada perhubungan yang dapat diberikan antara jangkamasa penyisihan dan asid humik yang dihasilkan. Asid humik yang dihasilkan daripada jangkamasa pengekstrakan dan penyisihan yang berbeza telah memberikan korelasi yang negatif. Penemuan daripada kajian ini mendapati bahawa pengisolasian asid humik daripada hemists dapat dilakukan dalam jangkamasa 10 jam berbanding jangkamasa purata yang ada kini dari 2 ke 7 hari. Maka ianya telah menyumbang kepada idea baru dalam penghasilan baja amonium-humate dan potasium-humate sebagai baja organik dalam bentuk cecair daripada tanah gambut. Bahagian kedua kajian ini adalah penghasilan baja organik daripada penyusunan semula asid humik dan fulvik. Baja yang terhasil daripada penyusunan semula asid humik dan fulvik ini akan diuji dalam makmal. Keberkesanan baja organik dalam meningkatkan kedapatan N adalah matlamat utama kajian ini. Ini adalah kerana, kehilangan N yang tinggi telah didapati daripada baja urea yang diberikan dipermukaan tanah. Sembilan rawatan baja [yang terdiri daripada urea (pepejal), urea (cecair), ammonium sulfat (pepejal), amonium sulfat (cecair), asid humik + urea, asid fulvik + urea, asid humik dan fulvik (diasidkan) + urea, asid humik dan fulvik (yang tidak diasidkan) + urea, dan tanah (tanpa apa-apa rawatan baja)] telah digunakan dengan matlamat untuk mengurangkan kehilangan N daripada penggunaan baja urea. Sistem aliran udara tertutup telah digunakan dalam menganggar kehilangan N daripada tanah. Penggunaan asid fulvik bersama-sama dengan urea telah mengurangkan peningkatan pH tanah begitu juga dengan pemeruapan amonia. Manakala penggunaan asid humik telah

mengurangkan pemeruapan amonia dengan signifikan. Hasil dari kajian ini telah menunjukkan bahawa keberkesanan baja cecair organik N yang telah diformulasi dalam mengurangkan kehilangan N dan seterusnya mengurangkan masalah pencemaran alam sekitar. Di samping dapat mengurangkan kehilangan N dengan baik, galakan kepada pertumbuhan dan tumbesaran pokok adalah faktor lain yang patut diberikan perhatian bagi memastikan keberkesanan baja yang telah dihasilkan. Maka, kajian di rumah kaca (bahagian ketiga kajian) dengan menggunakan pasu telah dibuat dengan menggunakan tujuh rawatan baja tidak termasuk amonium sulfat. Keputusan menunjukkan bahawa baja organik N dapat meningkatkan pengambilan nutrien (N,P dan K). Ianya juga berjaya menggalakkan keberkesanan penggunaan baja N terutamanya rawatan yang menggunakan asid fulvik. Maka baja yang diformulasi iaitu baja organik mempunyai potensi untuk bertindak sebagai baja alternatif dalam mengurangkan kehilangan N, mempertingkatkan pengambilan nutrien dan menggalakkan keberkesanan penggunaan baja N.

ACKNOWLEDGEMENTS

All praises are for Allah, the Exalted, Merciful and Magnificent. Many thanks and gratefulness go only to Allah for the strength given to me to deal with the trials and tribulations during my study. This trying moment could not be endured without Allah.

Special thanks also go to my supervisory committee namely Dr. Osumanu Haruna Ahmed (Chairman), Prof. Dato' Dr. Nik Muhamad Ab. Majid (member) and Prof. Dr. Mohd Khanif Yusop (member), for their support, encouragement, and constructive comments and suggestions during this research.

I sincerely thank my family members especially my dearest mother, Zaiton for her understanding and patience. Lastly, a big thank you to all of the technical staffs of the Soil Science Laboratory at Universiti Putra Malaysia Bintulu Campus, Sarawak, Malaysia for their assistance and help. A special thank you also goes to all of my dear friends, who consistently encouraged me to pursue my dream.

I certify that a Thesis Examination Committee has met on 10 Jun 2009 to conduct the final examination of Susilawati binti Kasim on her thesis entitled "Improving Liquid Fertilizer Urea Efficiency Using Humic Acid Additives Extracted from Tropical Peat" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

Japar Sidik Bujang, PhD
Professor
Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia
(Chairman)

Aminuddin Bin Hussin, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

Ahmad Husni Bin Mohd. Hanif, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

Katsutoshi Sakurai, PhD
Professor
Faculty of Agriculture
Kochi University, Japan
(External Examiner)



BUJANG KIM HUAT, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 13 July 2009

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

Osumanu Haruna Ahmed, PhD
Senior Lecturer
Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia
(Chairman)

Nik Muhamad Ab. Majid, PhD
Professor
Faculty of Forestry
Universiti Putra Malaysia
(Member)

Mohd Khanif Yusop, PhD
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

HASANAH MOHD. GHAZALI, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 17 July 2009



DECLARATION

I hereby declare that the thesis is based on my original work except for the quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

SUSILAWATI BINTI KASIM

Date : 7 July 2009

TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	vi
ACKNOWLEDGEMENTS	ix
APPROVAL	x
DECLARATION	xii
LIST OF TABLES	xvii
LIST OF FIGURES	xix
LIST OF ABBREVIATIONS	xx
 CHAPTER	
 1 GENERAL INTRODUCTION	 1
 2 LITERATURE REVIEW	 5
2.1 Fertilizer Consumption	5
2.2 Organic Fertilizers	5
2.3 Organic and Inorganic Fertilizers	7
2.4 Liquid and Foliar Fertilizers	8
2.5 Nutrient Use Efficiency	10
2.6 Nutrient Availability and Uptake	12
2.7 Effect of Fertilization	14
2.8 Soil Organic Matter	16
2.8.1 Classification and Decomposition	17
2.8.2 Identification and Quantification	19
2.8.3 Benefits and Functions	20
2.8.4 Buffering and Exchange Capacity	22
2.9 Organic Matter Additions to Soils	23
2.9.1 Crop Residues	23
2.9.2 Organic Amendments	24
2.9.3 Compost	25
2.9.4 Manure	27
2.9.5 Peat	27
2.10 Sarawak Peat	27
2.11 Organic Matter Composition	30
2.11.1 Humic Acids	30
2.11.2 Fulvic Acids	33
2.11.3 Humin	34
2.12 Differences among Humic Substances	35
2.13 Functional Groups	35
2.14 E ₄ /E ₆ Ratios	36



2.15	Humic Acid Isolation	38
2.15.1	Extraction	38
2.15.2	Fractionation	40
2.15.3	Purification	41
2.16	Roles of Humic Substances	41
2.16.1	Nitrogen Loss Control by Humic Acids	42
2.16.3	Interaction with Metal Ions	42
2.16.4	Nutrient Availability	42
2.16.5	Enhancement of Plant Growth	43
2.17	Urea	43
2.18	Soil Urease	44
2.19	Nitrogen Loss Pathways	44
2.19.1	Ammonia Volatilization	45
2.20	Materials Used to Control Ammonia Volatilization	48
2.20.1	Urease Inhibitors	48
2.20.2	Acidic and Non-acidic Materials	50
2.20.3	Ammonia Fixation by Organic Matter	50
2.20.4	Potassium, Calcium and Magnesium	51
2.20.5	Clay, Moisture and Temperature	51
2.21	Summary	52
3	GENERAL MATERIALS AND METHODS	53
3.1	Soil Type, Sampling and Drying	53
3.2	Soil Chemical Analysis	54
3.2.1	Exchangeable K, Ca and Mg Determination	54
3.2.2	Total N Determination	54
3.2.3	Organic Matter and Total Carbon Determination	55
3.2.4	Inorganic N Determination	56
3.3	Soil Field Capacity	57
3.4	Soil Texture	57
3.5	Humic Acid Isolation	58
3.6	Humic Acid Characterization	59
3.6.1	Total Carbon and Ash Content Determination	60
3.6.2	Functional Groups and Total Acidity Determination	60
3.6.3	E ₄ /E ₆ Determination	61
3.7	Determination of N, K, Ca, Mg and P in Maize Tissues	61
4	EFFECT OF EXTRACTION AND FRACTIONATION PERIOD ON THE YIELD OF A TROPICAL PEAT SOIL (HEMISTS) HUMIC ACIDS	64
4.1	Introduction	64
4.2	Materials and Methods	66

4.3	Results and Discussion	68
4.4	Conclusions	72
5	SIMPLE METHOD OF PURIFYING HUMIC ACID ISOLATED FROM TROPICAL HEMISTS (PEAT SOIL)	73
5.1	Introduction	73
5.2	Materials and Methods	74
5.3	Results and Discussion	76
5.4	Conclusion	80
6	AVAILABILITY OF AMMONIUM AND NITRATE IN MINERAL SOIL (<i>Typic Paleudults</i>) INCUBATED WITH ORGANIC BASED-N FERTILIZERS	81
6.1	Introduction	81
6.2	Materials and Methods	82
6.3	Results and Discussion	84
6.4	Conclusions	93
7	REDUCTION OF AMMONIA LOSS BY MIXING UREA WITH LIQUID HUMIC AND FULVIC ACIDS ISOLATED FROM TROPICAL PEAT SOIL	94
7.1	Introduction	94
7.2	Materials and Methods	96
7.3	Results and Discussion	97
7.4	Conclusions and Recommendation	107
8	EFFECT OF ORGANIC BASED N FERTILIZER ON DRY MATTER (<i>Zea mays L.</i>), AMMONIUM AND NITRATE RECOVERY IN AN ACID SOIL OF SARAWAK, MALAYSIA	108
8.1	Introduction	108
8.2	Materials and Methods	110
8.3	Results and Discussion	112
8.4	Conclusions and Recommendation	119
9	EFFECTIVENESS OF LIQUID ORGANIC-NITROGEN FERTILIZER IN ENHANCING NUTRIENTS UPTAKE IN CORN (<i>Zea mays</i>) PLANT	120
9.1	Introduction	120
9.2	Materials and Methods	122
9.3	Results and Discussion	124
9.4	Conclusions	138

10	GENERAL CONCLUSIONS	139
	REFERENCES	141
	APPENDICES	171
	BIODATA OF STUDENT	174
	LIST OF PUBLICATIONS	175



LIST OF TABLES

Table	Page
2.1 Absorption bands in the FTIR spectra of HA	31
2.2 E ₄ /E ₆ ratios of humic and fulvic acids	37
5.1 Effect of purification on selected chemical characteristics of humic acids (HA)	80
6.1 pH, exchangeable cations and ammonium at 30 days of incubation	91
7.1 Selected chemical properties of Nyalau Series	99
7.2 Average pH values of formulated liquid fertilizers	100
7.3 Cumulative NH ₃ loss for 30 days of incubation	103
7.4 Soil exchangeable NH ₄ ⁺ and available NO ₃ ⁻ contents for 30 days of incubation	104
7.5 Soil exchangeable K, Ca, Mg and Na for 30 days of incubation	104
8.1 Physico-chemical characteristics of Nyalau Series	113
8.2 Effect of different types of fertilizers on soil pH (using water and KCl) at 54 DAP	114
8.3 pH values of formulated liquid organic-urea mixture fertilizer	114
8.4 Effect of different types of fertilizers on dry matter production of maize at 54 DAP	115
9.1 Effect of different treatments on dry matter production at 54 DAP	126
9.2 Effect of different treatments on the concentration of N, P and K at 54 DAP	128
9.3 Effect of different treatments on the uptake of N at 54 DAP	129
9.4 Effect of different treatments on the uptake of P at 54 DAP	129



9.5	Effect of different treatments on the uptake of K at 54 DAP	129
9.6	Effect of different treatments on the concentrations of Ca, Mg and Na in leaves at 54 DAP	130
9.7	Effect of different treatments on the concentrations of Ca, Mg and Na in stems at 54 DAP	130
9.8	Effect of different treatments on the concentrations of Ca, Mg and Na in roots at 54 DAP	131
9.9	Effect of different treatments on the uptake of Ca, Mg and Na in leaves at 54 DAP	131
9.10	Effect of different treatments on the uptake of Ca, Mg and Na in stems at 54 DAP	132
9.11	Effect of different treatments on the uptake of Ca, Mg and Na in roots at 54 DAP	132
9.12	Effect of different treatments on N, P and K uptake efficiency	133
9.13	Effect of different treatments on total N, P and K uptake efficiency	134
9.14	Effect of different treatments on soil exchangeable cations at 54 DAP	135



LIST OF FIGURES

Figure	Page
4.1 Relationship between extraction period (Et) and humic acid yield (%)	69
4.2 Relationship between fractionation period (Ft) and humic acid yield (%)	70
4.3 Relationship between extraction period (Et) and pH	71
5.1 Effect of washing HA with distilled water on removal of K	77
5.2 Effect of washing HA with distilled water on removal of Ca	78
5.3 Effect of washing HA with distilled water on removal of Mg	78
5.4 Effect of washing HA with distilled water on removal of Na	79
6.1 Effect of treatments on soil pH _w after 30 days of incubation	85
6.2 Effect of treatments on soil pH _{KCl} after 30 days of incubation	86
6.3 Effect of treatments on exchangeable NH ₄ ⁺ after 30 days of incubation	87
6.4 Effect of treatments on exchangeable K after 30 days of incubation	88
6.5 Effect of treatments on exchangeable Ca after 30 days of incubation	89
6.6 Effect of treatments on exchangeable Mg after 30 days of incubation	90
7.1 Soil pH (using water) after 30 days on incubation	99
7.2 Soil pH (using KCl) after 30 days on incubation	100
7.3 Daily loss of ammonia for 30 days of incubation	101
8.1 Effect of different types of fertilizers on soil exchangeable ammonium at 54 DAP	115
8.2 Effect of different types of fertilizers on soil available nitrate at 54 DAP	116

LIST OF ABBREVIATIONS

NH ₄ ⁺	Ammonium ion
NO ₃	Nitrate
N	Nitrogen
P	Phosphorus
K	Potassium
Mn	Manganese
Zn	Zinc
CEC	Cation Exchange capacity
USA	United State of America
C	Carbon
HA	Humic Acids
FA	Fulvic Acids
PFP	Partial factor productivity
AE	Agronomic efficiency
RE	Recovery efficiency
PE	Physiology efficiency
Fe	Ferrum
Cu	Copper
B	Boron
S	Sulphur
K ⁺	Potassium ion
Mg	Magnesium
Ca	Calcium
SOM	Soil organic matter
NMR	Nuclear magnetic resonance
DOC	Dissolved organic carbon
Al	Aluminium
OH	Hydroxyl group
COOH	Carboxyl group
EC	Electrical conductivity
USDA	United State Department of Agriculture
FAO	Food and Agriculture Organization
UNESCO	United Nations Educational, Scientific, and Cultural Organization
H	Hydrogen
O	Oxygen
MHA	Mobile humic acids
CaHA	Calcium humic acids
β-HA	Beta humic acids
α-HA	Alpha humic acids
HCl	Hydrochloric acid
HF	Hydrogen fluoride
NaOH	Sodium hydroxide
N ₂	Nitrogen gas

Na	Sodium
ZnSO ₄	Zinc Sulphate
HS	Humic substances
NH ₄ NO ₃	Ammonium nitrate
EU	European Nation
NH ₃	Ammonia
NO	Nitric oxide
N ₂ O	Nitrous oxide
PAN	Potential available nitrogen
NBPT	N-(n-butyl) thiophosphoric triamide
TSP	Triple superphosphate
PG	phosphogypsum
DAP	Diammonium phosphate
NH ₄ Cl	Ammonium chloride
KCl	Potassium chloride
CaCO ₃	Calcium carbonate
FC	Field capacity
NH ₄ AOc	Ammonium acetate
g	gram
H ₂ SO ₄	Sulfuric acid
MgO	Magnesium oxide
KOH	Potassium hydroxide
AAS	Atomic absorption spectrophotometry
mg	milligram
NaHCO ₃	Sodium hydrogen carbonate
HNO ₃	Nitric acid
ppm	Part per million
ha	hectare
SAS	Statistical analysis system
DNMRT	Duncan's new multiple range test
LHA	Liquid humic acids
LFA	Liquid fulvic acids

CHAPTER 1

INTRODUCTION

Use of organic materials in enhancing soil fertility has been practiced for many years. Organic substances affect soil fertility by supplying minerals, improving soil structure, increasing soil microbial population, increasing cation exchange capacity (CEC) and buffering capacity of the soil. Additionally, they supply humic molecules which serve as macro and micronutrients carrier (Chen *et al.*, 2004; Olsen, 1986; Pilus Zambi *et al.*, 1982). Humic substances also directly affect plant growth and development by promoting various biochemical processes like photosynthesis and nucleic acid synthesis (Chen *et al.*, 2004; Nardi *et al.*, 2002; Young and Chen, 1997).

Enhancing macro and micro-nutrients availability in soil was a credit given by the use of humic substances. Increase of plant growth due to increase of nutrients uptake was commonly pronounced when humic substances are applied to the soil (Varanini and Pinton, 2001; Clapp *et al.*, 2001; Chen and Aviad, 1990). Since ions uptake depends on nutrient concentrations and the medium pH, the use of humic substances could be one of the appropriate approaches in enhancing nutrient availability and uptake in soil (Nardi *et al.*, 2002; Nardi *et al.*, 1991; Maggioni *et al.*, 1987).

As reported in previous studies, use of humic acid (HA) increased the uptake of macro and micro-nutrients of maize plant (Vaughan and Malcolm, 1985; Mylonas and McCants, 1980; Tan and Nopamornbodi, 1979). Organically bound form of micronutrients cations are more available to plants compared to inorganic forms of pools of insoluble inorganic precipitates and those held in primary minerals (Varanini and Pinton, 2006; Mandal and Mandal, 1986; Murthy, 1982). Thus, this approach was practical in boosting nutrients in soil.

Carbon is the other important element in promising healthy and good plant growth. Carbon in the form of soil organic matter can acts as a pool in sustaining soil fertility (Grigal and Ohmann, 1992). It also can improve water holding capacity and nutrient availability in soil (Lal *et al.*, 1998). Since peat can store high amounts of C, it could be a good source for formulating organic based fertilizers (Sorenson, 1993). As reported by Maltby and Immirzi (1993), tropical peats have more than 70 Gt carbon from an area ranging from 33 to 49 Mha. Thus it can be explored carefully and sustainably to formulate better fertilizer. Due to high CEC, acidic nature, water retention capability, and chelation characteristics, peats are suitable medium for organic fertilizer production (Tan, 2003; Stevenson, 1994).

Food production for the increasing world population also requires the development and application of new technologies to produce more food per unit